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RESEARCH NOTE

PHOTOCHROMISM AND PHOTOTROPISM: A TERMINOLOGY POLL

R. N. MACNAIR

U.S. Army Natick Laboratories, Natick, Massachusetts 01760, U.S.A.

(Received 16 April 1971; accepted 17 May 1971)

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THE FASCINATING photochemical phenomena of color change caused by incident light and the reversal of this change in the dark has for decades been called 'phototropy'. This term was originally borrowed from the biological sciences by Marckwald in 1899 [1], and it is still used by biologists to mean 'a turning of plant stems and foliage toward a source of light'. However, in 1950, 'photochromism' was introduced[2] to satisfy the apparent need for a term more accurately descriptive of photochemical color changes.

Although many chemists began using 'photochromism', others continued using 'phototropy(ism)' along with the biologists. Thus, considerable confusion resulted, particularly for users of abstract indices. Such confusion was recently discussed by the author[3] and the proposal made that 'photochromism' be used exclusively for describing reversible photochemical phenomena, leaving 'phototropism' for reference to the non-reversible biological phenomenon.

This discussion may have been noted because at the end of the same year in which it appeared *Chemical Abstracts* began indexing the terms according to their photochemical and photobiological meanings to avoid the confusion. Now *Chemical Abstracts* is indexing photochemical phenomena exclusively under 'photochromism' even when authors use 'phototropism' in their discussions[4]. But the possibility of semantic confusion in the minds of readers is not eliminated because 'phototropism' is still in photochemical use throughout the world even in review articles[5]. Therefore, it seems appropriate to point out a consensus of the views of photochemists on the use of these terms. Approximately 250 photochemists in countries throughout the world including the United States, Canada, England, France, Germany, Israel, Italy, Japan, Sweden and Switzerland were polled.* The response was very gratifying as 145 (58 per cent) returned the questionnaire and many provided comments and discussion.

Photochromism vs. Phototropism

The proposal to use 'photochromism' in photochemical literature and leave 'phototropism' for primary use in photobiological literature was found acceptable to a large

*The mailing list for the poll was compiled through personal contacts, from the mailing list for the 'Symposium on Reversible Photochemical Processes' held in Dayton, Ohio, May 1-3, 1967, and from the attendance lists of the Gordon Research Conferences on Organic Photochemistry held at Tilton, N.H., in 1965 and 1967.

majority of the scientists who responded to the poll; 143 out of 145 (98.6 per cent) indicating that they would use the term in future publications. The proposal to eliminate the term 'phototropism' from chemical terminology was found acceptable to a somewhat lesser degree, 118 out of 145 (81.4 per cent) agreeing to its elimination. However, a few photochemists apparently believe (and correctly so) that phototropism is still useful and appropriate in specific situations, for example, where light causes changes in several properties being discussed in one article.

Other terms

'Chromotropism', meaning a color change brought about by some un-named stimulus, received favorable comments from some and tacit approval from other photochemists. This mild response might help explain why the term 'photochromotropism' introduced about ten years ago[6] never 'caught on'. The latter is a bit more cumbersome even though philologically more complete and probably would not be used in place of the moderately acceptable former term.

Reversible photochromism

The only meaning now absent philologically in the preferred term 'photochromism', aside from the understood action 'to turn' or 'change', is the connotation of reversibility. This has been a concept impossible to include thus far without lengthening the term and/or introducing possible ambiguity and therefore making it undesirable once again. Two cases in point are the terms 'photallochromism' and 'photopalinchromotropism'[3]. Both of these terms received considerable opposition in the poll. Thus, in the interest of simplicity it is now proposed that the adjectives 'reversible' and 'irreversible' be used to modify 'photochromism' to connote such meaning. This proposal was coincidentally and independently made by 16 photochemists, about 11 percent of those responding to the poll.

This proposal is attractive because it does not change the present meaning of photochromism and thus removes the possibility of confusion between past and future literature. It is also versatile because it makes possible expressions such as partially, readily, slowly, speedily and thermally reversible photochromism as well as photochromism irreversible with *X* additive or *Y* treatment. Phrases such as visible, infrared and ultraviolet photochromism are also possible although perhaps not preferred because 'visible photochromism' seems redundant and 'infrared photochromism' is synonymous with 'thermochromism' to some photochemists. However, these phrases should be acceptable to most photochemists because non-visible regions of the spectrum are considered both as forms of 'light' (infrared and ultraviolet light) and as 'color' (monochromatic X-rays). All of these phrases could be developed into a concise notation system useable in abstracts as are the excited state transition notations, $n \rightarrow \pi^*$, and $\pi \rightarrow \pi^*$. For example, we might have $UV \rightarrow VIS$, red to blue, green to colorless, $\lambda 4820 \rightarrow \lambda 5630$, (all irreversible); $VIS \rightleftharpoons UV$ (reversible); or, $UV \rightleftharpoons VIS \rightarrow VIS$ (partially reversible with fatigue reactions) photochromism. However, no matter what an author uses for terminology, he should take the time and the space to make it absolutely clear what he means, either by reference or by defining his terms.

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